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EXTRA PUBLICATION.

ON RECENT CONTRIBUTIONS
TO OUR
KNOWLEDGE OF THE FLOOR OF THE NORTH ATLANTIC OCEAN.

BY

Sir JOHN MURRAY, K.C.B., F.R.S., D.Sc., Etc.,

AND

R. E. PEAKE, M. Inst. C.E.

LONDON:
THE ROYAL GEOGRAPHICAL SOCIETY,
1, SAVILE ROW.
1904.

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ON RECENT CONTRIBUTIONS TO OUR KNOWLEDGE OF THE FLOOR OF THE NORTH ATLANTIC OCEAN.*

By Sir **JOHN MURRAY**, K.C.B., F.R.S., D.Sc., etc., and
R. E. PEAKE, M. Inst. C.E.

INTRODUCTION.

The first attempt to show the floor of the North Atlantic Ocean by means of isobathic contour-lines is due to Lieut. M. F. Maury, of the United States Navy, who was for some years in charge of the Hydrographic Bureau at Washington. In the sixth edition of his 'Sailing Directions' published in 1854, he gives a map (Pl. xiv.) showing the depths of the North Atlantic, based principally upon soundings taken by several ships of the United States Navy between 1849 and 1853. This map is reproduced as an inset at the upper left-hand corner of the large bathymetrical map of the North Atlantic which accompanies this paper. A comparison of these two maps will show at a glance the progress of knowledge in regard to the bathymetry of the North Atlantic basin during the past half-century.

In his 'Physical Geography of the Sea,' published in 1855, Maury says, "There is at the bottom of this sea, between Cape Race, in Newfoundland, and Cape Clear, in Ireland, a remarkable steppe, which is already known as the Telegraphic Plateau. A company is now engaged with the project of a submarine telegraph across the Atlantic. It is proposed to carry the wires along this plateau from the eastern shores of Newfoundland to the western shores of Ireland. The great circle distance between these two shore-lines is 1640 miles, and the sea along the route is probably nowhere more than 10,000 or 12,000 feet deep."†

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* Map. p. 36.

† Maury, 'Physical Geography of the Sea,' p. 253 (1855).

In this extract it will be observed that Maury states that the sea-bed between Cape Race in Newfoundland and Cape Clear in Ireland is "already known as the Telegraphic Plateau." This, however, is the earliest publication in which we can find the term "Telegraphic Plateau." In the latest edition of his 'Sailing Directions,' * Maury devotes considerable space to a consideration of the bed of the North Atlantic, as regards its suitability for submarine telegraph cables, and the words "Telegraphic Plateau" are printed on his depth map (Pl. xi.), on a line running between Cape Race in the west and Cape Clear in the east. These words are not, however, printed on the earlier editions of the map.

With the view of tracing the origin of the term "Telegraphic Plateau," a letter was addressed to the U.S. Hydrographic Office on the subject, and the following reply was received, which is of much historic interest:—

Hydrographic Office, Washington, D.C., *December* 12, 1903.

SIR,

In reply to your letter of November 20, 1903, on the subject of the announcement of the discovery of a telegraphic plateau referred to in Maury's 'Sailing Directions,' 8th edition, vol. i., July, 1858, page 159, paragraph 2, the Hydrographic Office takes pleasure in furnishing you with the following information.

In Maury's 'Sailing Directions,' 5th edition, 1853, the telegraphic plateau is indicated on Plate xiv., constructed from deep-sea soundings reported prior to date of publication, but the name "Telegraphic Plateau" is not given to it.

In Maury's 'Sailing Directions,' 6th edition, 1854, the telegraphic plateau is more fully indicated on Plate xiv., which is a great improvement upon that in the preceding edition by the plotting of later deep-sea soundings; but the name "Telegraphic Plateau" has not yet been given to it (see the description of the Plate on pages 296 and 297).

In Maury's 'Sailing Directions,' 7th edition, 1855, page 155, paragraph 1, the telegraphic plateau, which is shown on Plate xiv., is described by that name, and although the description states that it "is already known as the 'telegraphic Plateau,'" it is considered by the Hydrographic Office that this is the announcement in the publications of this office referred to in paragraph 2, page 159, of Maury's 'Sailing Directions,' 8th edition, vol. i., 1858, as it is made in the same terms as the quotation from Maury's 'Physical Geography of the Sea,' given in paragraph 3, following paragraph 2, page 159, of Maury's 'Sailing Directions,' 8th edition, vol. i., 1858.

There is, however, an earlier document, a letter dated February 23, 1854, from Lieut. M. F. Maury, U.S.N. (Superintendent of the U.S. Naval Observatory and Hydrographical Office), to Prof. S. F. B. Morse, describing the bottom of the sea between Newfoundland and Ireland as "a plateau which seems to have been placed there especially for the purpose of holding the wires of a submarine telegraph, etc.," and speaking of it also as "the telegraphic plateau;" and this is doubtless the authority for the statement in the description in the 7th edition, and in the quotation in the 8th edition, that the plateau "is already known as the Telegraphic Plateau."

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* Maury, 'Explanations and Sailing Directions to accompany the Wind and Current Charts,' 8th edit., 2 vols. Washington: 1858 and 1859.

It must be borne in mind that this was not an announcement of a definite discovery made at a particular time, but was the conclusion gradually arrived at by the cumulative evidence obtained by soundings covering a number of years; so that the indication of the plateau on successively constructed and published plates, in editions five and six of the 'Sailing Directions,' the description of it in the letter of February 23, 1854, from Lieut. Maury to Prof. Morse, as "the telegraphic plateau," and finally its description in the 7th edition of the 'Sailing Directions' under the name of the Telegraphic Plateau, may well be considered as sufficient authority for the statement in the 8th edition of the 'Sailing Directions' that the discovery of a telegraphic plateau had been "duly announced in the publications of this office."

It is believed that copies of all the editions of the 'Sailing Directions' referred to were forwarded to the British Museum; but there is no record as to whether a copy of the letter of February 23, 1854, from Lieut. Maury to Prof. Morse, was also forwarded, and a copy of it is therefore herewith enclosed, trusting that it may be of interest to you.

Very respectfully,
(*Signed*) W. H. H. SOUTHERLAND,
Commander U.S. Navy, Hydrographer.

R. E. Peake, M. INST. C.E.,
Clark, Forde and Taylor,
4, Great Winchester Street, London, E.C., England.

The letter from Lieut. Maury to Prof. Morse, enclosed with the foregoing, being of considerable interest, is here printed by permission of the U.S. Hydrographer—

COPY.

National Observatory, February 23, 1854.

SIR,

Lieut. Minor informs me that you called at the Observatory the other day to make certain inquiries about the depth of the ocean between America and England, with a view to its bearings upon the subject of a submarine telegraph across the Atlantic.

I happened to be absent on a tour of duty at the north, and regret I did not have an opportunity of conversing with you upon this interesting subject.

You recollect that Congress has authorized the Secretary of the Navy to employ a small vessel or two of the navy to assist me in my researches touching the winds and currents of the sea, and to apply the *experimentum crucis* to certain discoveries connected therewith.

The last vessel employed on this service was the U.S. brig *Dolphin*, Lieut. Commanding C. H. Berryman. She is now laid up, but I hope she will be fitted out again in the spring, for there are still many highly interesting questions and useful problems that have arisen during these investigations into the laws of the great deep upon which she may throw light and enlarge the circle of their practical utility.

The examinations made by the *Dolphin* last year relate chiefly to that part of the ocean through which lies the great thoroughfare for ships engaged in commerce between this country and Europe. While thus employed, she carried a line of deep-sea soundings entirely across the Atlantic, and obtained all the information concerning the bottom of the deep sea between this and the British Islands that a submarine telegraphic company could desire.

From Newfoundland to Ireland the distance is about 1600 miles, and the bottom of the sea between the two places is a plateau which seems to have been placed there especially for the purpose of holding the wires of a submarine telegraph, and of keeping them out of harm's way. It is neither too deep nor too shallow. Yet it is so deep that the wires, being once landed, will remain for ever beyond the reach of vessels, anchors, icebergs, and drifts of any kind; and so shallow that the wires may be readily lodged upon the bottom. The depth of this plateau is quite regular, gradually increasing from the shores of Newfoundland to the depth of from 1500 to 2000 fathoms as you approach the other side. The distance between Ireland and Cape Charles in Labrador is somewhat less than the distance from any part of Ireland to the nearest point in Newfoundland. But whether it be better to lead the wires from Newfoundland or Labrador is not now the question; nor do I pretend to consider the question as to the possibility of finding a time calm enough, the sea smooth enough, a wire long enough, and a ship big enough to carry and lay a coil of wire 1600 miles in length. I simply address myself to the question in so far as the bottom of the sea is concerned; and as for that, the greatest practical difficulty will, I apprehend, be found after reaching soundings at either end of the line, and not in the deep sea.

A wire laid across from either of the above-named places on this side would pass to the north of the Grand Banks and rest on that beautiful plateau to which I have alluded, and where the water of the sea appears to be as quiet and as completely at rest as it is at the bottom of a mill-pond.

Now, you may wish to know the reasons for my inference that there are no perceptible currents and no abrading agents at work at the bottom of the sea upon the telegraphic plateau. I derive this inference from the study of a physical fact which I little dreamed, when I sought it, had any such bearings.

It is unnecessary to remind you of the germs which physical facts, even apparently the most trifling, are sometimes found to contain; for your own great achievements with the lightning has its root in the little physical fact that was first observed by a philosopher with regard to the legs of a dead frog. So, too, with regard to these deep-sea soundings, and the carefully labelled specimens from the bottom :—When asked, as I have often been, for the *cui bono?* touching these last, I have found myself under the necessity of answering the question by asking with Franklin, "What is the use of the new-born babe?"

Berryman brought up with Brooke's deep-sea sounding apparatus specimens of the bottom from this plateau. I sent them to Prof. Bailey, of West Point, for examination under his microscope. This he kindly gave them, and was quite as much surprised to find, as I was to learn, that *all* those specimens of deep-sea soundings are filled with microscopic shells—"*not a particle of sand or gravel exists in them.*"

These little shells, therefore, suggest the fact that there are no currents at the bottom of the sea whence they came; that Brooke's lead found them where they were deposited in their burial-place after having lived and died on the surface, and by gradually sinking were lodged on the bottom. Had there been currents at the bottom, they would have swept and abraded and mingled up with these microscopic remains the *débris* of the bottom of the sea, such as ooze, sand, gravel, and other matter. But not a particle of sand or gravel was found among them. Hence the inference that those depths of the sea were not disturbed either by waves or currents.

Consequently, a telegraphic wire once lodged there, it would remain as completely beyond the reach of accident as it would if buried in air-tight cases. Therefore, so far as the bottom of the deep-sea between Newfoundland or the mouth of the St. Lawrence and Ireland is concerned, the practicability of a submarine telegraph across the Atlantic is proved.

Respectfully, etc.,
(*Signed*) M. F. Maury, Lieut. U.S.N.

Prof. S. F. B. Morse,
Washington, D.C.

Lieut. Maury, in the last edition of his work, gives tables showing the soundings obtained up to the year 1857, on which his bathymetrical map was constructed, viz. those of the *Albany* (1850–51), the *Dolphin* (1851–52, Lieut. Lee), the *Dolphin* (1852–53, Lieut. Berryman), the *Jamestown* (1851), the *Plymouth* (1851), the *Portsmouth* (1851), the *Taney* (1849), the *Saratoga* (1850), the *Congress* (1851), the *John Adams* (1851), the *Susquehanna* (1851), the *St. Louis* (1852), and the *Saranac* (1853).

In Maury's map (which, as already stated, is reproduced as an inset to the bathymetrical map accompanying this paper) the depths are indicated by four shades of stippling, the darkest shade being used for depths less than 1000 fathoms, and the lightest shade for depths between 3000 and 4000 fathoms, those parts of the map where the depth was supposed to exceed 4000 fathoms being left blank.

In the year 1856, Lieut. Berryman, in the U.S.S. *Arctic*, sounded across the North Atlantic, the principal object being to verify the discovery of the so-called submarine ridge between Newfoundland and the British Isles, to which Maury had called attention, to which he had given the name of Telegraphic Plateau, and along which a company was preparing to lay a submarine cable. Berryman obtained samples of the deposit on the sea-floor from thirty-four points along this line, which were submitted to Prof. J. W. Bailey for examination and report.

In the following year (1857), Captain Dayman, in H.M.S. *Cyclops*, sounded along the great circle between Valentia in Ireland and Trinity bay in Newfoundland, to the north of Berryman's line. He used a modified form of Brooke's sounding-machine, and brought back many samples of deep-sea ooze, which were sent to Prof. Huxley for examination.

Again, in 1860 the British Government sent out H.M.S. *Bulldog* to make a comparative survey of the route for the Trans-Atlantic telegraph cable, accompanied by Dr. Wallich, who published an interesting account of the results in his 'North Atlantic Sea-bed.' * A great controversy arose as to whether some ophiurids, which came up clinging to the sounding-line, came from the bottom, and really lived at the great depth of 1260 fathoms in the ocean.

The deep-sea deposits collected by these last three and some of the immediately preceding expeditions, and their examination by scientific experts, created a very wide-spread interest. Bailey pointed out that some deposits obtained by Brooke in the Northern Pacific were chiefly composed of siliceous organisms, while those obtained in the North Atlantic were largely composed of the shells of calcareous organisms. Pourtalès announced the discovery of *glauconite* associated with *Globigerinæ* in deep water off the eastern coasts of the United States, and Bailey believed that this "well-defined greensand" was formed in the position from which it had been procured by the sounding-tube.

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* Wallich, 'North Atlantic Sea-bed.' London: 1862.

Some observers, like Maury and Bailey, held that the minute shells which made up the greater part of the Atlantic mud lived at the surface of the ocean and fell to the bottom after death. Ehrenberg, on the other hand, held that their true habitat was in the great depths from which they had been taken by the sounding-lead. Huxley discussed this question without coming to any definite conclusion, but on the whole he favoured Ehrenberg's view. This controversy was definitely settled during the *Challenger* expedition. The fifteen or twenty species of Foraminifera which make up the larger part of the Atlantic ooze were all found living in the surface waters of the ocean, and the distribution of the dead shells on the sea-floor corresponded exactly to the distribution of the living animals in the surface waters.*

Huxley found in the bottles containing the deep-sea oozes collected by Dayman a gelatinous substance with small round corpuscles, soluble in acid, which he called *coccoliths*. These last he regarded as the skeletal parts of a gigantic Moneron (*Bathybius*), which lived in the deep-sea ooze, and was probably wide-spread over the whole floor of the ocean in deep water.† This intimation caused something like a sensation among biologists. In concluding an interesting paper on the subject, Haeckel asked, What kind of organism is this *Bathybius?* "Have we not here the case of protoplasm coming continuously into being by creation? We stand here face to face with a series of dark enigmas, the answer to which we must hope to receive from future investigations." ‡ The *Challenger* Expedition found that the *coccoliths* were parts of a small calcareous Alga living, like the pelagic Foraminifera, in the surface waters of the ocean, and also that the viscous substance found in the bottles with the deep-sea oozes consisted of a gelatinous sulphate of lime thrown down from the sea-water associated with the oozes by the abundant addition of alcohol, which was poured into the bottles with the view of preserving the samples.

The examination of these early procured samples of Atlantic ooze also led to much controversy as to the origin of the volcanic and other mineral particles, which Bailey and others had observed in the samples. The *Challenger* Expedition also cleared up most of the difficulties connected with this subject by observing that large and small fragments of pumice—containing many of these minerals—were continually floating about on the surface of the ocean, and that they gradually became water-logged and sank to the bottom, where they disintegrated.

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* See Murray, "On the Distribution of the Pelagic Foraminifera at the Surface and on the Floor of the Ocean," *Natural Science*, vol. xi. p. 17 (1897).

† *Proc. Roy. Geogr. Soc.*, vol. xiii. p. 110 (1869).

‡ Haeckel, "Bathybius und das freie Protoplasma der Meerestiefen," *Jenaische Zeitschr.*, Bd. v. p. 499 (1870).

The observations of these early expeditions, and the controversies to which they gave rise, had a most important influence in directing the attention of scientific men to deep-sea problems, and ultimately led to the despatch of expeditions specially fitted for the exploration of the great ocean basins. The observations of Ross in the Arctic and Antarctic as to the depth at which marine organisms could live on the floor of the ocean had been overlooked or neglected, and it was very generally assumed that, as a result of Forbes's researches in the Mediterranean, a zero of life was soon reached in the abyss of the ocean.

The British Government fitted out the *Lightning* (1868), the *Porcupine* (1869), the *Shearwater* (1870), and finally the great *Challenger* Expedition, which explored all the great ocean basins from 1872 to 1876. In the years 1880 and 1882 the British ships *Knight Errant* and *Triton* explored the Faroe channel, with the view of testing some special questions raised during the *Porcupine* and *Challenger* expeditions.

Louis Agassiz and Pourtalès commenced the exploration of the deep water off the Atlantic coasts of America in 1867; and this work was continued with great vigour by his son, Dr. Alexander Agassiz, in the U.S. ships *Blake*, *Albatross*, and other ships from the year 1877 down to the present time. The *Gettysburg*, in 1876, and vessels of the U.S. Coast Survey, have at various times been engaged in the exploration of the North Atlantic in recent years.

In the years 1876 to 1878 the Norwegian Government sent out the *Vöringen* to investigate that part of the North Atlantic lying between Norway and Greenland.

In the years 1880 to 1883 the French Government ships, the *Travailleur* and *Talisman*, carried out deep-sea investigations in the eastern portion of the North Atlantic.

Since the year 1885 the Prince of Monaco has carried on oceanographical work nearly every summer in the North Atlantic, and is at present engaged in founding a large oceanographical institute at Monaco, on the shores of the Mediterranean.

The majority of the above-named expeditions engaged in the study of marine organisms by dredging, trawling, and tow-netting on the floor of the ocean and in the intermediate and surface waters, as well as in the examination of the temperature, specific gravity, composition of sea-salts, dissolved gases, and other physical and chemical investigations, sounding the ocean forming only a small part of the work carried out. A very large proportion of the information now available regarding the depth of the North Atlantic, which is represented on the chart accompanying this paper, has been derived from the sounding work carried out by the telegraph ships belonging to the different submarine cable companies, viz. the Telegraph Construction and Maintenance Company's steamers *Britannia*, *Scotia*, *Hibernia*, *Seine*, and *Great Eastern*; the India Rubber, Gutta Percha, and Telegraph Works Company's steamers *Silvertown* and *Dacia*; Messrs. Siemens Bros. & Co.'s steamer *Faraday*; the Anglo-American Telegraph Company's steamer *Minia*; and the Norddeutsche Seekabelwerke Company's steamer *Von Podbielski.*

DEPTH OF THE NORTH ATLANTIC OCEAN.*

The latest additions to our knowledge of the bathymetry of the North Atlantic are due to the expeditions of the Prince of Monaco, and to several cable-laying and cable-repairing ships. In the accompanying chart some of these additions are shown in red-coloured figures.

In May, June, and July, 1903, Captain H. S. Squares de Carteret, in the Anglo-American Telegraph Company's s.s. *Minia*, took 124 soundings between lat. 53° 5′ and 53° 28′ N., and between long. 34° 38′ and 35° 44′ W., in depths varying from 633 to 1737 fathoms. Seventeen of these soundings were taken in depths of less than 1000 fathoms, the shallowest being 633 fathoms. These soundings less than 1000 fathoms fall into two areas, which are separated from each other by considerably greater depths, as shown on a small inset in the lower right-hand corner of the bathymetrical chart accompanying this paper.

In the summer months of 1903, Mr. J. R. Brittle (accompanied by Mr. Peake), in Messrs. Siemens Bros. & Co.'s s.s. *Faraday*, took ninety-seven soundings between lat. 49° 42′ and 50° 9′ N., and long. 30° 11′ and 32° 35′ W., in depths varying from 1134 to 2207 fathoms, thirty of these soundings being in depths over 2000 fathoms. These soundings are to the west of the three elevations discovered by the s.s. *Faraday* in 1882, to which the name "Faraday Hills" has been applied. These soundings are also shown as an inset in the lower right-hand corner of the accompanying map. Mr. Peake, as well as Captain Carteret, brought home some most interesting deep-sea deposits and rock fragments, which will be referred to presently. The other soundings in the map, shown in red, were taken by the Prince of Monaco, and by the *Von Podbielski* Expedition in 1902. It is believed that this chart now shows nearly all the available information, as to the depth of the North Atlantic ocean, covering the area which is still spoken of as the "Telegraphic Plateau."

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* The Admiralty chart which accompanies this paper has been reproduced by the kind permission of Admiral Sir W. J. L. Wharton, K.C.B., the Hydrographer of the Admiralty.

The contour-lines of depth as laid down on this chart have been transferred to an equal-surface projection hemisphere, and the different areas have been measured with the planimeter. This investigation has been limited to the North Atlantic basin between lat. 20° and 60° N., excluding the partially enclosed seas along the margins, like the Mediterranean, the North sea, and the Gulf of Mexico, the total area dealt with being about 6,875,000 square geographical miles. The areas covered by water at different depths, and the percentages to the total area, are as follows:—

	Sq. geogr. miles.	Per cent.
0 to 1000 fathoms	1,338,000 =	19·5
1000 „ 2000 „	1,673,000 =	24·3
2000 „ 3000 „	3,184,000 =	46·3
Over 3000 „	680,000 =	9·9
	6,875,000	100·0

This table shows that by far the larger portion of the North Atlantic sea-floor, within the limits indicated, is covered by water between 1000 and 3000 fathoms in depth, equal to over 70 per cent. of the total area; while about 20 per cent. is covered by less than 1000 fathoms of water, and 10 per cent. by more than 3000 fathoms of water.

The shallow zone with depths less than 1000 fathoms forms a border around the North Atlantic basin, along the coasts of Africa and Europe on the east, along the Iceland plateau joining the British islands with Greenland by way of the Färoe islands and Iceland (which separates the deep basin of the North Atlantic from the deep basin of the Norwegian sea), and along the coast of Greenland and the entrance to Davis strait on the north, and along the North American coast on the west. The soundings within this zone, which includes what is called the continental slope, have shown in some places what are believed to be submerged river-basins or submarine gulleys, and the detailed examination of their configuration has led to an interesting discussion as to the changes between land and water during geological times.* This shallow zone also surrounds the islands and island groups, like the Canaries, Madeira, the Azores, and Bermuda, as well as the numerous submarine elevations that do not reach the surface, which have become a conspicuous feature in the bathymetry of the North Atlantic basin. The more important of these submarine elevations may be here indicated:—

(1) *Concepcion Bank*, on which the depth is 98 fathoms, off the African coast to the north of the Canary islands, in lat. 30° N., long. 13° W.

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* *See* Benest, "Submarine Gullies," *Geogr. Journ.*, vol. xiv. p. 405 (1899); Spencer, "Submarine Valleys off the American Coast and in the North Atlantic," *Bull. Geol. Soc. Amer.*, vol. xiv. p. 207 (1903); "On the Continental Elevation of the Glacial Period," *Geol. Mag.*, Dec. 4, vol. v. p. 32 (1898); "On the Eastern Margin of the North Atlantic Basin," *Geol. Mag.*, Dec. 4, vol. vi. pp. 97 and 145 (1899).

(2) *Dacia Bank*, covered by 47 fathoms of water, to the north-west of the Concepcion bank, in lat. 31° N., long. 14° W.

(3) An elevation with 533 fathoms on it, about midway between the Dacia bank and the Concepcion bank.

(4) *Seine Bank*, covered by 81 fathoms of water, to the north-east of Madeira, in lat. 34° N., long. 14° W.

(5) *Coral Patch*, with 362 fathoms on it, to the north-east of the Seine bank, off the Strait of Gibraltar, in lat. 35° N., long. 12° W.

(6) *Gettysburg Bank*, covered by 34 fathoms of water, to the north of the Coral Patch, off Cape St. Vincent, in lat. 36½ N., long. 11½ W.

(7) *Josephine Bank*, with 82 fathoms on it, to the west of the Gettysburg bank, in lat. 37° N., long. 14° W.

(8) An elevation with 800 fathoms on it, discovered in 1898 by the telegraph ship *John Pender*, off Vigo bay, in lat. 42° N., long. 11° W.

(9) *Porcupine Bank*, covered by 82 fathoms of water, off the west coast of Ireland, in lat. 50° N., long. 14° W.

(10) *Rockall Bank*, opposite the Hebrides, in lat. 58° N., long. 13½ W., with Rockall rising 70 feet above the water.

(11) *Elizabeth Bank*, with 21 fathoms on it, to the south of Iceland, in lat. 62° N., long. 17° W.

(12) An elevation with 690 fathoms on it, in lat. 56° N., long. 35° W.

(13 and 14) Two shallow areas with depths of 633 and 773 fathoms, discovered by the s.s. *Minia* in 1903, in lat. 50° N., long. 35° W.; these are shown in detail in a small inset at the lower right-hand corner of the large bathymetrical chart.

(15, 16, and 17) Three shallow areas with depths of 625, 730, and 982 fathoms, discovered by the s.s. *Faraday* in 1882, in lat. 50° N., long. 29° to 30° W., known as the "Faraday hills;" these are also shown in small inset at lower right-hand corner of bathymetrical chart.

(18) *Laura Ethel Bank*, with 36 fathoms on it, reported in 1878 in lat. 47° N., long. 39° W.

(19) *Sainthill Bank*, with 100 fathoms on it, reported in 1832 in lat. 43° N., long. 42° W.

(20) An elevation with 38 fathoms on it, to the south-east of Sable island, in lat. 43° N., long. 58° W.

(21) *Chaucer Bank*, with 48 fathoms on it, reported in 1850 to the north of the Azores, in lat. 43° N., long. 29° W.

(22) An elevation with 80 fathoms on it, reported in 1877 to the south-west of the Azores, in lat. 34° N., long. 34° W.

The bottom around the Azores is very irregular,* deep water exceeding 1000 fathoms being found in most of the passages between the islands, with shallows and banks here and there. The most important bank is that discovered and carefully examined by the Prince of Monaco to the south of Fayal, called the Princesse Alice bank, the summit of which is covered by 24 fathoms of water. In the deep water outside the 1000-fathoms line surrounding the Azores, a few soundings less than 1000 fathoms have been recorded. For instance, 960 fathoms to the west of Fayal; 903 fathoms to the south-west of Flores near a sounding of 2000 fathoms (which apparently represent a rise above and a fall below the normal level of the bottom in this locality); 840 fathoms to the north-east of Graciosa; and still farther to the north-east there is a sounding of 979 fathoms, remarkable as being in close proximity to the Peake deep, in which the depth is 3284 fathoms.

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* An admirable bathymetrical chart of the Azores, prepared for the Prince of Monaco by Prof. J. Thoulet, was published by the Musée Océanographique at Monaco in 1903. This chart has been carefully compared with the depth map accompanying this paper.

The area of the North Atlantic sea-floor covered by water between 1000 and 2000 fathoms in depth, within the limits already indicated, is about one-fourth of the total area. This zone extends along the eastern, northern, and western borders of the map, outside the shallower zone just dealt with, but it also extends uninterruptedly from the northern border down the centre of the ocean as far as the equator. This central ridge or plateau is probably the most striking characteristic in the bathymetry of the North Atlantic basin. It is very irregular in outline, being widest in the northern portion between lat. 30° and 50° N. To this wide northern portion the name "Dolphin Plateau" was given in the bathymetrical hemispheres published in 1895 with the summary volumes of the '*Challenger* Reports,' while to the narrow southern portion the name "Connecting Plateau" was applied, because it was supposed to connect the "Challenger Plateau" running down the centre of the South Atlantic with the "Dolphin Plateau" in the North Atlantic; subsequent soundings have shown that the connection is broken for a short interval at the equator in long. 18° W., where the depth slightly exceeds 2000 fathoms. There are several areas in which the depth is less than 2000 fathoms, surrounded by water exceeding 2000 fathoms in depth, which may be here enumerated—

(1) A large area around Madeira, and enclosing also the Seine and Josephine banks, in lat. 32° to 37° N., long. 14° to 19° W.

(2) A sounding in 1700 fathoms, to the east of the Chun deep, in lat. 27° N., long. 28° W.

(3) A sounding in 1720 fathoms, to the west of the Chun deep, in lat. 25° N., long. 38° W.

(4) A sounding in 1828 fathoms, still farther to the west, in lat. 26° N., long. 42° W.

(5) A sounding in 1675 fathoms, to the south-east of Nantucket island, in lat. 40° N., long. 66° W.

(6) A sounding in 1600 fathoms, to the west of the Azores, in lat. 39° N., long. 44° W.

(7) A sounding in 1975 fathoms, to the north of the last-mentioned, in lat. 41° N., long. 44° W.

(8) A sounding in 1958 fathoms, to the south-east of the Great Bank of Newfoundland, in lat. 41° N., long. 49° W.

(9) A sounding in 1790 fathoms, to the east of the Great Bank of Newfoundland, in lat. 44° N., long. 46° W.

(10) A considerable area with depths ranging from 1073 to 1974 fathoms, between the Sainthill and Laura Ethel banks already referred to, in lat. 45° N., long. 40° W.

(11) A sounding of 1800 fathoms, opposite the Bay of Biscay, in lat. 46° N., long. 17½° W.

(12) A considerable area with depths ranging from 1529 to 1983 fathoms, to the west of Ireland, in lat. 52° to 53° N., long. 22° to 26° W.; it seems doubtful whether this area is entirely surrounded by water exceeding 2000 fathoms in depth (as shown on the map), or whether it is continuous on its west side with the 1000 to 2000 fathoms area.

The area of the North Atlantic sea-floor covered by water between 2000 and 3000 fathoms in depth, within the limits indicated, is nearly one-half of the total area. This zone forms two large irregular areas, one to the east, the other to the west, of the central ridge or plateau, the 2000-fathom contour-line being of a very sinuous description, and it encloses certain areas in which the depth exceeds 3000 fathoms (to be dealt with in the next paragraph), as well as certain areas in which the depth is less than 2000 fathoms (as already indicated). The eastern area extends as far north as lat. 53° N., while the western one reaches lat. 58° N., the northern extremities of both areas being very irregular, with a few outlying soundings exceeding 2000 fathoms, apparently surrounded by shallower water.

The area of the North Atlantic sea-floor covered by more than 3000 fathoms of water, within the limits indicated, is about one-tenth of the total area. To those parts of the ocean-basins in which the depth is known to exceed 3000 fathoms, the term "deeps" has been applied, and distinguishing names assigned to them. There are ten such "deeps" in that part of the North Atlantic basin now under consideration, which may be here briefly referred to in the order of their size *—

(1) The *Nares deep*, the largest and most important in the North Atlantic, extends beyond the southern limit of the map accompanying this paper, the maximum depth of 4662 fathoms occurring to the south of lat. 20° N. To the north of lat. 20° N., it covers an area of about 505,000 square geographical miles, stretching from off the Bahamas and

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* The "deeps" as given in our previous paper (1901) have been somewhat modified by more recent soundings. During the laying of a cable in the spring of 1904, indications were met with of a depth of about 1800 to 2000 fathoms between the Thoulet and Sigsbee deeps. This would appear to show that a hill of about 1000 fathoms in height rises from the floor of the ocean in this neighbourhood.

Antilles in a north-easterly direction to the south of Bermuda, as far north as lat. 35° N. in long. 47° W. It includes three soundings less than 3000 fathoms, the shallowest one being 2858 fathoms.

(2) The *Chun deep*, lying to the south-west of the Azores, stretching from the southern limit of the map in lat. 20° N. to lat. 29° N., and from long. 30° to 39° W. It covers an area of about 82,000 square geographical miles, and has a maximum depth of 3318 fathoms.

(3) The *Suhm deep*, to the south of the Great Bank of Newfoundland, between lat. 37° and 40° N., and long. 47° and 58° W. It covers an area of about 64,000 square geographical miles, and has a maximum depth of 3549 fathoms.

(4) The *Thoulet deep*, a short distance to the west of the Suhm deep, in lat. 39° to 41° N., long. 59° to 61° W. It covers an area of about 9000 square geographical miles, and has a maximum depth of 3195 fathoms.

(5) The *Sigsbee deep*, to the west of the Thoulet deep, in lat. 39° to 40° N., long. 62° to 64° W. It covers an area of about 7000 square geographical miles, and has a maximum depth of 3318 fathoms.

(6) The *Keltie deep*, to the north-west of Bermuda, in lat. 34° N., long. 68° W., covering an area of about 3000 square geographical miles, based on a sounding of 3250 fathoms.

(7) The *Mill deep*, to the west of Bermuda and south-west of the Keltie deep, in lat. 32° N., long. 77° W., covering a similar area, and based on a sounding of 3013 fathoms.

(8) The *Monaco deep*, to the north-west of the Canary islands, in lat. 31° N., long. 25° W., covering a similar area, with a maximum depth of 3400 fathoms.

(9) The *Peake deep*, to the north-east of the Azores, in lat. 43° N., long. 20° W., covering a similar area, and based on soundings of 3284 and 3265 fathoms.

(10) The *Libbey deep*, to the south-west of the Sigsbee deep, in lat. 39½° N., long. 64° W., covering an area of about 1000 square geographical miles, and based on a sounding of 3125 fathoms.

From the foregoing description, it is abundantly evident that the bed of the North Atlantic presents the greatest diversity in its configuration. From its central ridge or plateau, as well as from still deeper water, there arise elevations which form islands, like the Azores, Madeira, the Cape Verdes, and Bermuda. Many other elevations do not, however, rise to the surface of the waves, but form submarine hills, some of which are only submerged a few hundred feet, and the slopes of which may be very steep or even precipitous.

On the other hand, what we have called "deeps" descend about 20,000 feet below the level of the waves. If the highest mountain in the world were placed in the Nares deep, it would form an island the summit of which would be about 1000 feet above the water.

In comparison with Maury's map, it will be observed that the 4000-

fathoms area shown on that map to the south of the banks of Newfoundland has disappeared. Its position, however, corresponds with that now occupied by the Suhm, Thoulet, Sigsbee, and Libbey deeps. Further, it will be noticed that Maury's simple contour-lines have become far more complicated and sinuous in character, and that the large central area, on his chart, less than 2000 fathoms in depth is entirely altered in character and reduced in width, its south-western extension being now occupied by the north-eastern portion of the Nares deep. On Maury's map there is also an entire absence of isolated submarine elevations, which are now known to be so numerous.

THE TEMPERATURE, SALINITY, AND CURRENTS IN THE WATERS OF THE NORTH ATLANTIC.

A number of bottom temperatures were taken on board the s.s. *Faraday* between May 28 and June 30, 1903, in depths varying from 1550 to 2164 fathoms, which are valuable as supplying information regarding the temperature at the bottom in the part of the North Atlantic visited by the *Faraday*. A few observations have been recorded to the north, south, and east of this locality, indicating on the whole a lower temperature than that observed at similar depths in the North Atlantic.

The readings vary from 37°·0 to 38°·0, the higher readings being recorded in the lesser depths, as shown in the following table:—

A temperature of	38°·0	Fahr.	is recorded at	1550 fathoms.
„	37°·9	„	„	1561 „
„	37°·8	„	„	1636 „
„	37°·7	„	„	1778 „
„	37°·6	„	„	1926 „
„	37°·4	„	„	1776 and 1953 fathoms.
„	37°·3	„	„	1898 „ 2164 „
„	37°·2	„	„	1980 „ 2055 „
„	37°·2	„	„	2000 „ 2039 „
„	37°·0	„	„	1989 „ 2049 „

Mr. Peake records a temperature of 49° Fahr. at the surface on May 28, 1903, while in June the surface temperature varied from 53° to 58°. Captain Carteret to the north-west found the surface temperature in May 40°, in June 45°, and in July 48°; while the temperature of the air in May was 34° to 48°; in June 45° to 48°, and in July 46° to 50°.

The temperature, salinity, and currents of the North Atlantic present much greater variety and contrast than in any other of the great ocean basins. This arises from the general atmospheric circulation, which drives a large body of tropically heated water of high salinity into the basin chiefly through the Gulf Stream, and at the same time forces a great mass of cold water of low salinity down from the Arctic ocean.

The surface water of the North Atlantic basin in and around the

Sargasso sea has a very high salinity; for instance, between lat. 20° and 30° N., on the meridian of 40° W., the mean annual specific gravity of the surface water exceeds 1·0275, to the north of lat. 40° N. on the same meridian it exceeds 1·0270, while as far north as lat. 53° N. in mid-ocean it exceeds 1·0265. These readings are much higher than those observed in the Pacific at similar latitudes, and the mean annual surface temperature also is higher, latitude for latitude, in the North Atlantic than in the North Pacific, except in the western part of the basin, in the neighbourhood of Newfoundland and Nova Scotia. This part of the North Atlantic is remarkable for the extremely wide range of temperature in the surface waters throughout the year, a range exceeding 50° Fahr. having been recorded over a large area extending off the North American coast to the south of Nova Scotia, seaward to near long. 50° W. A similar wide range of temperature occurs in the surface waters of the Pacific, off the coast of Asia in the Sea of Japan, but is limited to a much smaller area. This large annual range of temperature is due to the fact that the surface is occupied by cold waters coming from polar regions at one season, and by warm waters coming from tropical regions at another season.*

The warm dense water, sinking beneath the surface, raises the temperature of the underlying layers, and thus we find at all depths down to the bottom a temperature above the mean and higher than at similar depths in the other ocean basins. Thus, at a depth of 100 fathoms, the mean temperature of the waters of the North Atlantic exceeds 70° Fahr. in the neighbourhood of the West Indies, and over a large part of the basin it exceeds 60° Fahr., while in the eastern part of the basin it exceeds 50° Fahr. as far north as the north of Ireland; the mean temperature of the entire ocean at this depth is 60°·7 Fahr. At a depth of 200 fathoms the mean temperature in the North Atlantic exceeds 60° Fahr. over a considerable area in the central and western parts of the basin, and it exceeds 50° Fahr. in the eastern part of the basin as far north as Ireland; the mean temperature of the whole ocean at this depth is 50°·1 Fahr. At a depth of 300 fathoms the mean temperature is higher in the North Atlantic than in any other part of the world, a large part of the basin as far north in the eastern portion as the English channel having a mean temperature exceeding 50° Fahr., while in the central and western parts of the basin the mean temperature exceeds 60° Fahr. over certain areas. A mean temperature of 60° Fahr. is quite unknown in any other ocean basin at this depth, the nearest approach being in the southern Indian ocean, where the mean temperature is 53° Fahr. For the entire ocean the mean temperature at this depth is 44°·7 Fahr. At a depth of 400 fathoms a mean temperature exceeding 55° Fahr. occurs in the central and western parts of the North Atlantic basin, while the mean temperature exceeds 50° Fahr. as far north as Cape Finisterre; the mean temperature for the whole ocean at this depth is 41°·8 Fahr. At a depth of 500 fathoms the mean temperature exceeds 50° Fahr. in the western, central, and eastern parts of the North Atlantic basin, and as far north as the north of Scotland it exceeds 46° Fahr.; the mean temperature for the entire ocean at this depth is 40°·1 Fahr. At a depth of 600 fathoms a mean temperature exceeding 51° Fahr. is recorded off the entrance to the Mediterranean, and the larger portion of the North Atlantic basin has a mean temperature exceeding 40° Fahr.; the mean temperature for the entire ocean at this depth is 39°·0 Fahr. At still greater depths the mean temperature of the water over the larger part of the North Atlantic basin is always above the mean for the whole ocean, and off the entrance to the Mediterranean the mean temperature is always higher than that recorded in any other part of the world at similar depths.*

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* See Murray, "On the Annual Range of Temperature in the Surface Waters of the Ocean, and its Relation to other Oceanographical Phenomena," *Geographical Journal*, vol. xii. p. 113 (1898).

The temperature of the water at the bottom of the North Atlantic basin in deep water is between 35° and 40° Fahr. over nearly its whole extent, with a higher temperature in the lesser depths and a lower temperature at the entrance to Davis strait and in the Arctic ocean. The average temperature over the floor of the North Atlantic is about 2° Fahr. above the average temperature at the bottom of the Indian and South Atlantic oceans, while the temperature of the bed of the Pacific is intermediate between these.†

Deposits now forming on the Floor of the North Atlantic.

The nature of the deposits now forming on the bed of the North Atlantic are largely determined by the physical conditions of the basin. In the preceding paragraphs we have indicated the manner in which the temperature, salinity, and circulation differ from similar phenomena in other parts of the ocean. It must also be remembered that of the 45,000,000 square miles of land which drain into the ocean as a whole, about 26,000,000 square miles—or considerably more than one-half—drain into the Atlantic ocean, and principally into the North Atlantic, or the partially enclosed seas which pour their waters into it, as the Mediterranean, Baltic, and Arctic seas. It thus happens that detrital matters from rivers and icebergs are more widely distributed over the floor of the North Atlantic than in the other ocean basins.

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* See Buchan, 'Challenger Report on Ocean Circulation.' London: 1895.

† See Murray, "On the Temperature of the Floor of the Ocean, and of the Surface Waters of the Ocean," *Geographical Journal*, vol. xiv. p. 34 (1899).

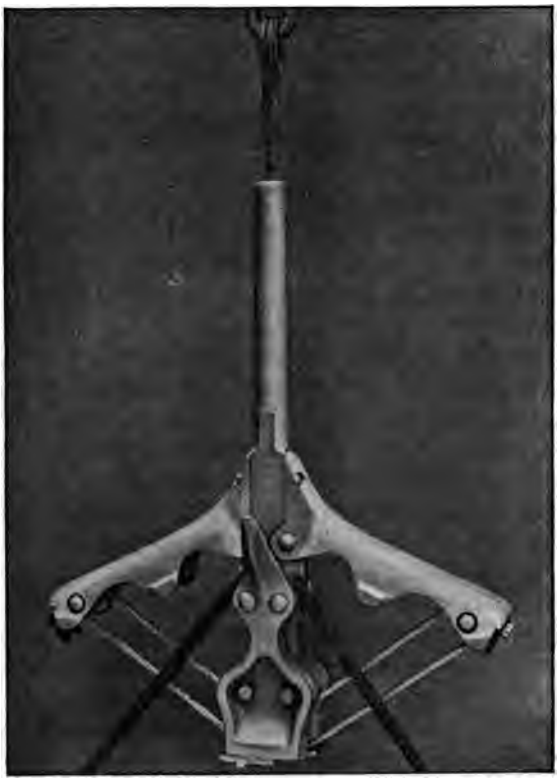
During the *Challenger* Expedition, rock fragments from icebergs and floating ice were traced as far south as the latitude of the Azores, and nearly as far east as this group of islands. In the accompanying map lines are drawn showing the limits within which icebergs may be seen at different seasons of the year; but on the sea-floor minerals and rock fragments which have evidently been ice-borne can be traced much beyond the limits shown by these lines.

The samples of rock fragments collected from the sea-bed by the *Minia* and *Faraday* expeditions in 1903 have been carefully examined by John S. Flett, Esq., D.SC., of the Geological Survey. In his report, which is appended to this paper, Dr. Flett comes to the conclusion that these rock fragments have for the most part been transported by ice from Greenland; in no other way can their variety, appearance, and association be satisfactorily accounted for. In many instances these fragments were coated with a brown deposit of the peroxide of manganese; this coating is on the surface of the fragment which projected above the deposit on which it was lying.

In the opinion of telegraph engineers, the grapnel used for hooking the cables tows at a depth of about six inches, and in so doing frequently catches rock. Within regions affected by floating ice, these rocks may quite well all be transported fragments; but it is also possible that there may be outcrops of bare rock *in situ*, or covered only by a thin layer of Globigerina ooze.

It was hoped that some of the specimens of rocks obtained on the *Faraday* 1903 expedition might have been broken from the projecting solid rock, as the employment of the "Lucas grapnel" afforded the means of obtaining such specimens, a result which was not possible with any grappling apparatus previously employed. The action of this instrument as a stone-breaker will be readily understood by reference to the annexed illustrations. When a rock is hooked by one of the prongs, a strain is brought to bear on the wire rope sufficient to break the bolts which fasten the two wings to the stock and keep them open. As soon as these bolts are broken, the two wings come down on the boss with great force and break off any piece of rock that interferes with their closing. In this way several pieces of rock were broken off and brought up in the grapnel during the *Faraday* Expedition in 1903. In most cases the evidence, as a whole, seems to show that these fragments were broken off transported boulders. There seems, however, to be almost conclusive evidence that volcanic rocks of recent origin do project above the deposits on the sea-bed in deep water; but as yet there is no trustworthy evidence that any crystalline or stratified rocks do project in this manner.

In addition to material transported from the land, there are now forming, in the North Atlantic, great deposits of glauconite and phosphate of lime. These are being laid down principally along the continental slopes in depths from 100 to 1000 fathoms, especially along those shores where there is a great annual range of temperature. Glauconite seems to be intimately associated with deposits containing many fragments of continental rocks in process of alteration and decomposition, and phosphate deposits are most abundant where changing physical conditions bring about a great destruction of marine organisms. In the spring of 1882, it is believed that the sea-bed for hundreds of square miles off the Atlantic coasts of the United States was covered to a depth of 6 feet with dead fish and other marine organisms, whose destruction was brought about by the lateral shifting of ocean currents from different sources and of very different temperatures.* In



CUTTING AND HOLDING GRAPNEL, LUCAS'S PATENT.

This grapnel is designed to hook the bight of a cable, to cut and drop one end, and to grip and raise the other end to the surface. It is dragged over the bottom with the folding arms in the position shown above. When the cable has been hooked, the bight is raised until it becomes tight; the strain then breaks the bolts that kept the arms extended; the tension on the wire rope causes the arms to fold down on the shank, securely gripping the cable on one side and cutting off the other.

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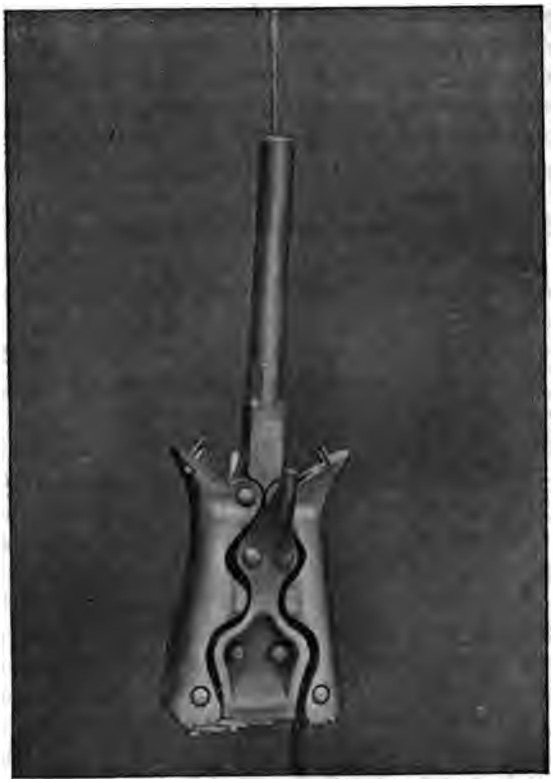
* See Murray's "Annual Range of Temperature in the Surface Waters of the Ocean and its Relation to other Oceanographic Phenomena," *Geographical Journal*, vol. xii. p. 18 (1898).

all regions of the ocean where similar phenomena take place large deposits of phosphate of lime and glauconite are now in process of formation.

The most striking feature of the deeper marine deposits of the North Atlantic is the large number of calcareous shells which they contain. It has now been definitely ascertained that the vast majority, in bulk, of these calcareous shells belong to animals and calcareous algæ which live in the surface waters of the ocean. These organisms are much more abundant in the warm, salt, tropical waters than in the colder and less salt waters towards the poles and along the continents where rivers pour their fresh water into the ocean. On the other hand, pelagic organisms which secrete silica for their shells, skeletons, and frustules, are more abundant in the colder and less salt water towards the poles and off the mouths of great rivers, where the oceanic water is diluted by water from the land.



CUTTING AND HOLDING GRAPNEL, LUCAS'S PATENT.

This view shows the grapnel when the bolts have been broken; the folding arms grip one end of the cable in the serpentine-shaped space between them and the shank, the knives having closed together and cut away the part of the cable not required.

In no part of the North Atlantic are the remains of siliceous organisms sufficiently abundant on the sea-floor to form deposits to which the names of Radiolarian ooze and Diatom ooze have been applied. In all probability this arises from the relatively large amount of detrital matter carried into the North Atlantic on the one hand, and on the other to the very large body of very warm and salt water which occupies all the central portions of the basin.

In the tropical waters of the Atlantic there are about a dozen species of pelagic Pteropods and other molluscs living at the surface, and about twenty species of pelagic Foraminifera. These species gradually disappear from the surface as the cold water of the Arctic seas is reached. In Arctic water there is only one dwarfed species of pelagic Foraminifera, and one species of shelled Pteropods and no calcareous pelagic Algæ. The distribution of the dead shells over the bed of the Atlantic corresponds exactly with the distribution of the living organisms in the surface waters, but the distribution is by no means uniform as to quantity. There is much evidence to show that the destruction of these organisms is much more frequent along lines in the ocean where currents of different temperatures meet and mingle, and consequently in these areas there is a much more rapid accumulation of their dead shells on the sea-bottom.

The depth of the ocean is likewise a most important factor in determining the distribution of these dead calcareous shells on the sea-bed. In relatively shallow depths—say less than 1000 fathoms—the calcareous shells of nearly every species of pelagic organism can be detected in the deposits, and it may be assumed that the deposit is accumulating at a rapid rate. With increasing depth the thinner and more delicate shells slowly disappear from the deposit. In still greater depths the heavier and thicker shells are riddled with holes and have a corroded appearance, and in the greatest depths of the ocean not a trace of these calcareous shells can be found in the deposit, which there becomes a pure red clay or a Radiolarian ooze. It seems evident that as soon as the organism dies in the surface waters, a solution of the carbonate of lime shell sets in through the action of the gases dissolved in sea-water or set free through the decomposition of the soft parts of the organism. In the shallow parts of the ocean the shells reach the bottom before much solution has taken place, and they in consequence accumulate there, forming Pteropod and Globigerina oozes, but in the greater depths the shells are either wholly or largely dissolved before they reach the bottom, and no accumulation takes place. A consideration of the various conditions just indicated appears to explain how it is that in one part of the ocean a Globigerina ooze is still met with at a depth of 2500 fathoms, while at the same depth in another part a pure red clay with only a few calcareous organisms may be met with. It is, in consequence, extremely difficult to form any satisfactory opinion as to the rate at which a

Pteropod or Globigerina ooze is forming on the floor of the North Atlantic ocean.

A point of considerable interest brought out by these recent cable-repairing expeditions may afford a hint regarding the rate of deposition of Globigerina ooze on the floor of the North Atlantic. The two repairs referred to in this paper were carried out, (1) by the s.s. *Minia* in lat. 53° N., and (2) by the s.s. *Faraday* in lat. 50° N. In the first case a cable thirty years old was lifted and repaired in 1500 fathoms, and in the second case a cable twenty-eight years old was lifted and repaired in 2300 fathoms. No attempt had previously been made to raise a submarine cable of this great age in deep water, and the life of a cable under such conditions had been regarded as equal to about thirty years, but these two repairs have shown that a much longer period must be granted. The cable lifted by the *Faraday* in 2300 fathoms in 1903 was raised in 1888, about 200 miles to the eastward, by Mr. F. R. Lucas in the s.s. *Scotia.* The specimens of the cable recovered in 1903 were submitted to Mr. Lucas for examination, and he is quite convinced that no deterioration has taken place during the interval of fifteen years. This is ascribed to the fact that the cable was covered with Globigerina ooze at the date of its recovery in 1888, as it has now become generally recognized that a submarine cable is preserved when in contact with this deposit. As, in 1888, the cable had been submerged for thirteen years, this implies a rate of deposition of one inch of the deposit in some period between 0 and 13 years, but as the deterioration noted in the cable, especially in the hemp serving, had probably taken some years to effect, it is perhaps fair to assume a period of ten years for the accumulation of a layer of the deposit one inch in thickness, in lat. 50° N., long. 31° W., depth 2000 fathoms. Another example bearing on this question is afforded by the St. Vincent—Pernambuco cable lifted in 1883 from a depth of 1900 fathoms in lat. 2° 47′ N., long. 30° 24′ W., after having been submerged for nine years. This cable proved to be in much better condition than the North Atlantic cables examined after being laid for a similar period, and this is doubtless due to the more rapid deposition of the Foraminifera shells in the warmer waters of the equatorial Atlantic than in the colder waters of the North Atlantic, so that the cable became more rapidly covered over by the Globigerina ooze. There are many instances of cables having been recovered from a bottom of Globigerina ooze, showing a good and a bad side, the supposition being that the good side was buried in the ooze; the preservative nature of this deposit has also been shown on bright wire, of which many specimens (such as sounding-wire and pieces of the 1858 Atlantic cable) have been recovered in excellent condition, after being submerged for many years.

If, therefore, the above theory be correct—and there appears to be fair ground for its acceptance—it furnishes an approximate idea of the rate of deposition on the bed of the ocean, a point on which, up to the present time, it has been impossible to form even the vaguest estimate.

It has been suggested that where cables have become covered with Globigerina ooze, it has been due to the sinking of the cable into the ooze, and not to the deposition of the marine shells upon the cable. No doubt at the first impact with the bottom the cable may bury itself to the extent of perhaps one-quarter of its diameter, but if further sinking occurred, it would undoubtedly be at a rate that would soon place the cable beyond the reach of the grapnel. It has been found in all parts of the world that cables lying on the Globigerina ooze can, even after many years, always be hooked, and as an ordinary grapnel only tows to a depth of about 6 inches, why should the action of sinking be arrested within this limit?

Cables become buried to a considerable depth in rivers and in shallow water off coasts where exposed to the deposition of materials brought down by rivers. The same result is brought about by drifting sand or by landslips, where the bank from shoal to deep water is broken down, probably by the discharge from submarine rivers or by earthquakes. In deep water, however, when sufficiently far removed from the shore to be free from land deposit, cables have never been found to become buried in this manner.

The cruise of the s.s. *Britannia* across the North Atlantic in 1899, while surveying the routes for telegraph cables between Germany and New York, and between Ireland and Nova Scotia by way of the Azores, formed the subject of a paper published by the Royal Geographical Society in 1901, illustrated by a map of the North Atlantic showing the distribution of the marine deposits throughout that basin, and a bathymetrical chart of the region around the Azores.* From that paper the following table is extracted, showing the area of the floor of the North Atlantic between the parallels of 30° and 60° N. lat. covered by the different kinds of deposits:—

	Sq. geogr. miles.	Percentage.
Globigerina ooze	2,967,000	60·94
Blue mud	1,303,000	26·76
Red clay	526,000	10·80
Green mud	32,000	0·66
Volcanic mud	20,000	0·41
Pteropod ooze	18,000	0·37
Coral mud	3,000	0·06
	4,869,000	100·00

It will be seen from this table that three types of deposits, viz.

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* 'On the Results of a Deep-sea Sounding Expedition in the North Atlantic during the Summer of 1899,' by R. E. Peake, M. INST. C.E.; with Notes on the Temperature Observations and Depths, and a Description of the Deep-sea Deposits of this Area, by Sir John Murray, K.C.B., LL.D., D.SC., F.R.S. Royal Geographical Society (Supplementary Papers). 1901.

Globigerina ooze, red clay, and blue mud, cover no less than 98½ per cent. of the area indicated, while the remaining four types represented, viz. green mud, volcanic mud, pteropod ooze, and coral mud, cover together only 1½ per cent. The principal deposit-type is Globigerina ooze, which occupies 61 per cent. of the bottom of the North Atlantic between 30° and 60° N.

APPENDIX I.

REPORT ON THE ROCK SPECIMENS AND SOME OF THE OOZES COLLECTED BY THE S.S. "FARADAY" AND S.S. "MINIA" FROM THE BED OF THE NORTH ATLANTIC IN 1903.

By **JOHN S. FLETT**, D.Sc., F.R.S.E.

I. *Rock Specimens.*

SPECIMEN *a.*—S.s. *Minia*, Sounding 122, lat. 53° 12′ 15″ N., long. 53° 44′ W., 872 fathoms. Fine, buff-coloured, crystalline limestone, without traces of organic structures. It effervesces readily with cold dilute hydrochloric acid, and under the microscope consists of small crystals of calcite, forming a mosaic in which there are brown patches stained with limonite.

SPECIMEN *b.*—S.s. *Minia*, Sounding 120, lat. 53° 8′ 45″ N., long. 35° 42′ W., 844 fathoms. Olivine basalt, fine grained, not distinctly porphyritic. It contains olivine, brownish augite, and lath-shaped plagioclase, with iron oxides, and the structure is of the "sub-ophitic" type. Not vesicular. The olivine has weathered to serpentine and limonite. There are a few small phenocrysts of felspar.

SPECIMEN *c.*—S.s. *Minia*, Sounding 4, lat. 53° 20′ N., long. 34° 40′ W., 1397 fathoms. Porphyritic andesite or andesitic basalt. In this rock there are a few small phenocrysts of plagioclase felspar and brownish augite in a ground-mass composed of small elongated plagioclases and grains of augite and magnetite. It contains no olivine, and is not vesicular. All the minerals are well preserved.

SPECIMEN *d.*—S.s. *Minia*, Sounding 63, lat. 53° 14′ 30″ N., long. 35° 15′ W., 1440 fathoms. Perlitic tachylite, perfectly fresh, with a few skeleton crystals of olivine and phenocrysts of plagioclase and greenish augite. The dark brown ground-mass is very abundant, and is very free from microliths and spherulites; here and there it shows small rounded steam cavities.

SPECIMEN 1.—S.s. *Faraday*, Station 62, lat. 50° 3′ N., long. 30° 46′ 45″ W., 1460 fathoms. Biotite gneiss, fine grained and somewhat granulitic in texture. It is very rich in microcline, but contains practically no muscovite; quartz appears in fine veins or strings which are parallel to the foliation, as indicated by the biotite. Orthoclase is common, but soda-lime felspars are scarce. The biotite is brown, and is not abundant.

SPECIMEN 2.—Same locality. Fine-grained granular basalt, very similar to specimen *b*, but without olivine. It contains many small phenocrysts of brownish augite.

SPECIMEN 3.—Same locality. A sheared biotite granite or granite-gneiss, showing cataclastic structures throughout, and much decomposed. It has evidently originally contained biotite, but this has been entirely replaced by epidote and chlorite.

Specimen 4.—S.s. *Faraday*, Station 25, lat. 49° 56′ 17″ N., long. 31° 22′ 46″ W., 1599 fathoms. Fine-grained biotite gneiss or biotite schist, with a yellow-brown biotite, like that which occurs in rocks which have been subjected to a high temperature. This rock looks very much like a biotite hornfels.

Specimen 5.—S.s. *Faraday*, July 2, 1903 (grapnel), lat. 50° 2′ 40″ N., long. 30° 27′ 36″ W., 1840 fathoms. Uralitic ophitic diabase, with abundant pale-brown augite extensively replaced by uralitic hornblende; there are no traces of olivine. The ophitic structure has been very perfect. The rock contains also a little biotite and skeleton crystals of ilmenite, together with secondary epidote, chlorite, and calcite.

Specimen 6.—S.s. *Faraday*, July 2, 1903 (grapnel), lat. 50° 3′ N., long. 30° 29′ 30″ W., 1840 fathoms. Coarsely spherulitic obsidian, perhaps rhyolitic in character, and somewhat decomposed. It contains no phenocrysts except a few skeletons of felspar, and the mass of the rock consists of large irregular spherulites, often zoned and stained brown by decomposition. There are some features which resemble the variolitic phases of the diabases, but I have never seen any of them exactly like this.

Specimen 7.—S.s. *Faraday*, Station 33, lat. 49° 52′ 17″ N., long. 31° 30′ 12″ W., 1239 fathoms. Impure felspathic sandstone.

Specimen 8.—S.s. *Faraday*, Station 53, lat 50° 1′ 40″ N., long. 31° 7′ 52″ W., 2049 fathoms. Fine-grained hornblende granite, almost free from biotite, but containing much sphene and secondary epidote. In the hand specimen it shows a slight foliation.

Specimen 9.—S.s. *Faraday*, June 24, 1903 (grapnel), lat. 50° 52′ N., long. 31° 1′ W., 2039 fathoms. A rock of unusual type, and also decomposed. It contains brown hornblende, chlorite after augite or biotite, and plagioclase felspar, with iron ores and apatite. The structure is ophitic; probably this is a fine-grained proterobase; there is no trace of olivine, and most of the hornblende is undoubtedly primary.

Specimen 10.—S.s. *Faraday*, June 18, 1903 (grapnel), lat. 50° 0′ 20″ N., long. 31° 5′ 47″ W., 2069 fathoms. Biotite granite gneiss. In the hand specimen the rock is well foliated, but the microscopic slide has strongly marked granitic characters.

Specimen 11.—S.s. *Faraday*, June 4, 1903 (grapnel), lat. 49° 54′ 54″ N., long. 31° 30′ 12″ W., 1134 fathoms. Hornblende schist, consisting of dark green hornblende and felspar, with a small amount of epidote, sphene, and iron oxides.

Specimens 12 and 13.—Same locality. Both of these are grey, fine-grained, crystalline limestones, which show no organic structures.

Specimen 14.—Same locality. Garnetiferous biotite granite gneiss.

Specimen 15.—Same locality. Fine-grained and much decomposed basalt.

Specimen 16.—S.s. *Faraday*, July 15, 1903 (grapnel), lat. 49° 50′ N., long. 31° 53′ W., 1960 fathoms. Granular crystalline limestone.

Specimen 17.—S.s. *Faraday*, July 2, 1903 (grapnel), lat. 50° 2′ 40″ N., long. 30° 27′ 36″ W., 1840 fathoms. Fine arenaceous shale, in which the bedding is clearly visible.

Specimen 18.—Same locality. Decomposed hornblendic rock, probably a hornblende schist, covered with a dark spongy crust which, when heated, becomes magnetic and also reacts strongly for manganese. Evidently a manganese nodule forming on a pebble on the sea-floor.

The rock specimens, of which the above is a descriptive list, varied in size from 4½ inches in diameter down to small pebbles the size of a bean. Some of the larger stones have that blunted form characteristic of boulders which have formed part of a ground moraine, and one or two of them show distinct glacial scratches. For the most part, however, they have a weathered surface covered with a dark brown crust, and any striations they may have at one time possessed have disappeared. The limestones have a smooth corroded form, as if they had been subjected to some solvent action. Some of the smaller pebbles are quite angular, but there are others which are as well rounded as if they had been taken from a stream or a sea-beach.

The number of different kinds of rock is very great in comparison with the total number of specimens. There are three crystalline limestones (two of which may possibly have come from the same mass), three basalts, which have many points of resemblance to one another, and five biotite gneisses (no two of which are very like). The other rocks are—andesite, diabase, tachylite, spherulitic obsidian, granite, sandstone, shale, proterobase, hornfels (?), and hornblende gneiss.

The majority of the rocks belong to the metamorphic group, the specimens of granite gneiss being especially abundant. There are also hornblende schists and metamorphic limestones. Two sedimentary rocks are in the collection, viz. sandstone and shale. Neither of these contained any fossils, so that their age is doubtful. On looking through the petrographical literature of Greenland, I have found that all these might have come from that region, and the predominance of metamorphic rocks would be easily explicable on that hypothesis. The gneisses, in particular, are very similar to those described by Danish geologists in their accounts of the geology of Greenland. The basalts and andesite could also be closely matched, with one or two exceptions. Unfortunately, there is no single rock in the collection which does not belong to a fairly common type (except No. 9), and there is none that presents peculiarities of such a nature that its source can be established with certainty. But the general facies of the assemblage strongly reminds one of the rocks of the Greenland province.

Most of the rocks are hard or tough, *e.g.* the granites and gneisses. The only soft rocks represented are limestones and shales (and of the latter there was only one small specimen). This may indicate that they are mainly the englacial or sub-glacial *débris* of land ice.

The tachylite (specimen *d*) and the spherulitic obsidian (specimen 6) are not like any rocks which I have seen described from Greenland. The latter of these was not certainly identified, and if it be a variolite, much decomposed, may quite well have been derived from the same source as the basalts and diabases. But the former, in its perfect freshness and other characters, exactly resembles some of the sideromelans figured by Murray and Renard in the '*Challenger* Report on Deep-Sea Deposits,' Plate xvi., and belongs to a type which is wide-spread over the sea-floor. This was the only pebble which I was inclined to regard as probably of local origin.

II. GLOBIGERINA OOZES.

Eleven samples of Globigerina ooze were included in the collection of specimens sent in for examination. They were of very mixed character, and varied in colour from yellow-brown to creamy-white. It was suspected that the amount of impurity present determined the shade of yellow exhibited, and subsequent tests established the general accuracy of this conclusion. The oozes which contained the largest percentage of carbonate of lime were nearly white. They were also very friable when dry, and readily broke down into a fine powder, which consisted mostly of tests of *Globigerina* and other Foraminifera, mixed with fine *débris*. But the more impure samples, which were of a pale brown colour, were sometimes very coherent when dry, and resembled clays rather than fine oozes in their physical properties.

In one or two cases the fine oozes contained small rounded or angular pebbles, which were not sufficiently large to be sliced for microscopic examination. The only alternative was to crush them and examine the powder. They all proved to be black volcanic glass, translucent, and brown coloured on the thin edges of fine splinters, and pale brown and transparent when reduced to a fine powder and mounted in Canada balsam. They contained a few small microliths in the abundant glassy base. Plagioclase felspar and augite were the only minerals recognized as present in large crystals; olivine was not identified with certainty. They were apparently of the same nature as the tachylite described above (specimen *d*), though not of exactly the same mineral composition.

Attention was especially directed to the nature of the insoluble impurities of these oozes, as being likely to supply information regarding the particular conditions of deposition prevailing in the area from which they were taken. With this end in view, a portion of certain samples was dissolved in very dilute hydrochloric acid, the residue filtered off, dried, and weighed. It was found to consist of fine impalpable, argillaceous particles, the nature of which could not be determined from their optical properties, and of small mineral fragments from 0·01 millimetre in diameter upwards. These latter were separated by a process of levigation or vanning. On account of the small amount of material available, it was not possible to make this separation a quantitative one, and only rough estimates could be formed of the relative percentages of coarse and fine particles.

In the following list the samples are arranged according to the amount of impurity present, as estimated by the colour of the dried specimen:—

Sounding 50.—Lat. 53° 8′ N., long. 35° 10′ W., depth 1715 fathoms.
„ 4.—Lat. 53° 20′ N., long. 34° 40′ W., depth 1397 fathoms.
„ 8.—Lat. 53° 17′ N., long. 34° 42′ W., depth 1533 fathoms.
„ 38.—Lat. 53° 12′ N., long. 34° 58′ W., depth 1608 fathoms.
„ 53.—Lat. 53° 14′ N., long. 35° 10′ W., depth 1548 fathoms.
„ 98.—Lat. 53° 14′ N., long. 35° 30′ W., depth 1444 fathoms.
„ 18.—Lat. 53° 13′ N., long. 34° 45′ W., depth 1373 fathoms.
„ 94.—Lat. 53° 8′ N., long. 35° 29′ W., depth 773 fathoms.
„ 75.—Lat. 53° 10′ N., long. 35° 21′ W., depth 1363 fathoms.
„ 124.—Lat. 53° 15′ 30″ N., long. 35° 44′ W., depth 983 fathoms.
„ 115.—Lat. 53° 12′ 45″ N., long. 35° 37′ W., depth 1293 fathoms.

A preliminary examination of the insoluble residues of all these specimens was made, and as it was clear that they were essentially of similar character, it was decided to concentrate attention on four selected samples, and to study their minerals as carefully as possible.

Sounding 50.—Brown or buff-coloured, gritty, containing one pebble (a quarter of an inch in diameter) of black volcanic glass. Insoluble residue, 43·77 per cent. Minerals: Quartz (granitic), often brown stained, up to 1 millimetre in diameter, mostly well-rounded, but the smaller fragments were often angular or subangular; orthoclase, decomposed and rounded; microcline (rare); weathered oligoclase; also perfectly fresh sanidine, oligoclase, andesine, and labradorite (in angular splinters and cleavage flakes). These last contained augite microliths and glass cavities. Brown volcanic glass, occasionally fluidal or finely vesicular, frequently perlitic, but not spherulitic. Colourless, transparent pumice in fine shreds and splinters with concave outlines. Less common were—magnetite in grains and small octahedra; pyroxene of two varieties, pale green and clear brown; chlorite; glauconite in rounded cryptocrystalline aggregates; olivine, perfectly fresh in angular fragments; one small grain of pink garnet. Among the doubtful minerals were hyperthene, zircon, and epidote.

Sounding 53.—A tough, pale brown deposit with many Foraminifera. Insoluble residue, 54·14 per cent. Minerals: Small rounded quartzes up to 0·3 millimetre in diameter, weathered orthoclase, sanidine, oligoclase, microcline, brown glass, shreds of pumice, hornblende, green and brown augite, magnetite.

Sounding 98.—Pale brown Globigerina ooze. Insoluble residue, 31·12 per cent. Minerals: Quartz, mostly rounded, up to 0·3 millimetre in diameter; orthoclase, microcline, sanidine, oligoclase, andesine, labradorite, fragments of colourless pumice and of brown glass, green hornblende, augite (brown and green), magnetite, olivine, epidote, glauconite; also a doubtful isotropic mineral.

Sounding 124.—Pale, creamy-white, coherent Globigerina ooze. Insoluble residue, 20·62 per cent. Recognizable mineral particles in this were very few, and formed not more than 2 or 3 per cent. of the sample; they were mostly brown and colourless volcanic glass, angular pieces of felspar, green augite. Quartz was either absent or very scarce.

The remaining specimens were examined in a more cursory fashion, and the general results of the whole investigation may be summarized as follows. The mineral impurities were recognizably of three kinds, viz.—volcanic particles, minerals formed *in situ*, and transported fragments. The purest ooze (No. 124) contained only the first and second of these, and resembled in all respects the typical, highly calcareous Globigerina oozes described in the *Challenger* Report. The volcanic minerals varied greatly in abundance, but not much in character, in the different slides. The amount of transported sediment was still more variable, but was always greatest in those specimens which yielded the highest proportion of insoluble residue. In some cases it seemed to be largely of a fine-grained or argillaceous character; in others it was coarse and sandy.

The volcanic fragments included the different types of glass, together with sanidine, oligoclase, andesine, and labradorite, green and brown augite, olivine, magnetite, and perhaps zircon, apatite, and enstatite. They had certain characters by which it was always possible to identify them. In no case did they show decomposition, except in the brown glass, which sometimes was altering to palagonite around its edges. Even the olivine was entirely fresh. Many of them had thin pellicles of glassy ground-mass adherent to their surfaces. Sometimes felspar, green augite, and magnetite were seen embedded in similar glass. None of them was in the least rounded; they always had the form of angular splinters and cleavage flakes.

The glauconite, which occurred in rounded aggregations with cryptocrystalline structure, was probably the only mineral which had been formed *in situ*.

The transported sediment included quartz, orthoclase, oligoclase, microcline, green hornblende, chlorite, epidote, and garnet. Material of this nature was very frequently rounded and water-worn. The quartz showed this especially well; much of it was as well rounded as the sand of rivers or the sea-shore. In a less degree it was characteristic of the felspars, but the epidote and hornblende were quite angular, probably because the perfect cleavage of these minerals causes them to split up readily. No less significant is the fact that all the sedimentary materials were probably derived from crystalline rocks very similar to the larger pebbles. The quartz invariably contained fluid cavities or rutile hairs, and had come from granite or gneiss, except a few grains which had the appearance of the quartz of quartz schists or quartzites. The felspars were usually decomposed and full of scaly mica and other secondary products. The green hornblende was like that of granites and hornblende schists. The microcline, epidote, and garnet are very characteristic of the older crystalline rocks.

The abundance of quartz was further established by means of heavy fluids, partly by Sollas's diffusion column, partly by actual separations. It was estimated that quartz formed rather more than one-half of the coarser ingredients in the insoluble residue of No. 50.

APPENDIX II.

LISTS OF SOUNDINGS TAKEN BY THE S.S. "MINIA" AND S.S. "FARADAY" IN THE NORTH ATLANTIC IN 1903, INDICATING THE TYPE OF DEPOSIT AND PERCENTAGE OF CALCIUM CARBONATE.

I. *Soundings by s.s. "Minia."*

Sounding.	Latitude north.	Longitude west.	Depth. Fathoms.	Deposit.	$CaCO_3$ per cent.
No.	° ′ ″	° ′ ″			
1	53 18 0	34 38 0	1545	Globigerina ooze	—
2	53 16 0	34 40 0	1542	—	—
3	53 18 0	„	1550	—	—
4 (*c*)	53 20 0	„	1397	Globigerina ooze, containing rock fragment described by Dr. Flett	50
5	53 20 0	34 41 0	1356	Globigerina ooze	—
6	53 14 0	34 42 0	1530	Small stones	—
7	53 16 0	„	1544	Globigerina ooze	—
8	53 17 0	„	1533	„ „	60
9	53 19 0	„	1421	—	—
10	53 15 0	34 43 0	1537	—	—
11	53 17 0	„	1546	—	—
12	53 18 30	„	1537	Globigerina ooze	—
13	53 20 0	„	1277	—	—
14	53 17 0	34 44 0	1544	—	—
15	53 24 0	„	1071	Rock	—
16	53 27 0	„	1118	„	—
17	53 28 0	„	1200	—	—
18	53 13 0	34 45 0	1373	Globigerina ooze	60
19	53 15 0	„	1473	—	—
20	53 17 0	„	1734	—	—
21	53 18 0	„	1485	Globigerina ooze	—
22	53 20 0	„	1495	—	—
23	53 17 0	34 46 0	1369	—	—
24	53 17 0	34 48 0	1363	Rock	—
25	53 16 0	„	1350	„	—
26	53 9 0	34 50 0	1303	—	—
27	53 12 0	„	1495	—	—
28	53 15 0	„	1260	—	—
29	53 16 0	„	1072	—	—
30	53 18 0	„	1200	Globigerina ooze	—
31	53 14 0	34 52 0	1300	—	—
32	53 16 0	„	1283	—	—
33	53 17 0	„	1142	—	—
34	53 19 0	„	1144	Globigerina ooze	—
35	53 21 0	„	1174	—	—
36	53 17 0	34 55 0	1000	Globigerina ooze	—
37	53 9 0	34 58 0	1480	—	—
38	53 12 0	„	1608	Globigerina ooze	60
39	53 15 0	„	1313	„ „	—
40	53 18 0	„	1063	„ „	—
41	53 21 0	„	1055	—	—
42	53 5 0	35 0 0	938	Rock	—
43	53 15 0	„	1253	Small stones	—
44	53 18 0	„	994	Rock	—
45	53 17 0	35 2 0	1089	Small stones	—
46	53 8 0	35 5 0	1422	—	—
47	53 11 0	35 5 0	1545	—	—
48	53 14 0	„	1539	Globigerina ooze	—
49	53 17 0	„	1182	—	—
50	53 8 0	35 10 0	1715	Globigerina ooze, described by Dr. Flett	56·23
51	53 10 0	„	1714	—	—
52	53 12 0	„	1737	—	—

Sounding.	Latitude north.	Longitude west.	Depth. Fathoms.	Deposit.	$CaCO_3$ per cent.
No.	° ′ ″	° ′ ″			
53	53 14 0	„	1548	Globigerina ooze, described by Dr. Flett	45·86
54	53 17 0	„	788	Rock	—
55	53 19 0	„	655	„	—
56	53 21 0	„	633	„	—
57	53 24 0	„	748	„	—
58	53 10 0	35 11 0	1298	„	—
59	53 14 30	„	1450	—	—
60	53 9 0	35 14 0	1434	—	—
61	53 14 0	„	1513	—	—
62	53 13 0	35 15 0	1335	—	—
63(*d*)	53 14 30	„	1440	Volcanic glass fragment, described by Dr. Flett	—
64	53 18 0	„	1182	—	—
65	53 8 0	35 17 0	1344	—	—
66	53 12 0	„	1235	—	—
67	53 14 0	„	1521	—	—
68	53 16 0	„	1429	—	—
69	53 17 0	35 18 0	1258	—	—
70	53 8 0	35 19 0	1314	—	—
71	53 10 0	„	1463	—	—
72	53 13 0	„	1187	—	—
73	53 17 0	35 20 0	1296	—	—
74	53 8 0	35 21 0	1315	—	—
75	53 10 0	„	1363	Globigerina ooze	70
76	53 10 0	35 22 0	1420	„ „	—
77	53 13 0	„	1141	—	—
78	53 8 0	35 23 30	1126	—	—
79	53 10 0	„	1428	Globigerina ooze	—
80	53 11 0	„	1390	—	—
81	53 12 0	„	1370	Globigerina ooze	—
82	53 7 0	35 25 0	871	Rock	—
83	53 10 0	„	1300	Globigerina ooze	—
84	53 15 0	„	1335	—	—
85	53 10 0	35 25 30	1176	—	—
86	53 10 30	„	1181	Globigerina ooze	—
87	53 11 0	„	1357	—	—
88	53 12 0	„	1513	—	—
89	53 8 0	35 27 0	850	Globigerina ooze, small stones	—
90	53 9 45	„	909	Rock	—
91	53 11 30	„	1328	Globigerina ooze	—
92	53 12 30	„	1407	„ „	—
93	53 15 0	„	1494	—	—
94	53 8 0	35 29 0	773	Small stones, Globigerina ooze	40
95	53 9 0	35 30 0	1020	Rock	—
96	53 10 0	„	1176	—	—
97	53 13 0	„	1315	—	—
98	53 14 0	„	1444	Globigerina ooze, described by Dr. Flett	68·88
99	53 15 0	„	1443	—	—
100	53 17 0	„	1204	—	—
101	53 8 30	35 31 30	1055	Globigerina ooze	—
102	53 11 30	„	1154	„ „ and small stones	—
103	53 13 0	„	1096	Rock	—
104	53 16 0	„	1400	Globigerina ooze	—
105	53 13 0	35 32 30	1063	Rock	—
106	53 9 0	35 33 30	884	„	—
107	53 10 0	„	832	„	—
108	53 11 0	„	1139	—	—
109	53 13 0	„	1286	Globigerina ooze	—

Sounding.	Latitude north.	Longitude west.	Depth. Fathoms.	Deposit.	$CaCO_3$ per cent.
No.	° ′ ″	° ′ ″			
110	53 10 0	35 35 0	969	Rock	—
111	53 13 0	,,	1294	Globigerina ooze	—
112	53 13 45	,,	1400	,, ,,	—
113	53 14 30	,,	1394	—	—
114	53 17 0	,,	1424	Globigerina ooze	—
115	53 12 45	35 37 0	1293	,, ,,	70
116	53 10 0	35 38 0	1067	Rock	—
117	53 12 30	,,	1142	,,	—
118	53 15 30	,,	1400	Globigerina ooze	—
119	53 6 45	35 42 0	1030	Rock	—
120 (*b*)	53 8 45	,,	844	Sand, shell, stones, described by Dr. Flett	—
121	53 10 30	35 44 0	1013	Rock	—
122 (*a*)	53 12 15	,,	872	Stones and shells, described by Dr. Flett	—
123	53 14 0	,,	872	—	—
124	53 15 30	,,	983	Globigerina ooze, described by Dr. Flett	79·38

Captain Carteret sent us the material from fourteen of his soundings, and the results of Dr. Flett's examination are given in Appendix I. The deposits are all Globigerina oozes, in which the percentage of calcium carbonate varies from 47 to 79; in four cases this percentage has been determined by chemical analysis, and in other cases we have estimated the percentage by inspection.

II. *Soundings by s.s. "Faraday."*

No.	Date.	Latitude.	Longitude.	Depth.	Deposit.	$CaCO_3$ per cent.	Remarks.
		° ′ ″	° ′ ″	Fathoms.			
1	May 27, 1903	49 47 15 N.	32 27 30 W.	2049	—	—	
2	„ 27 „	49 47 1	32 27 20	1988	—	—	Piece of brown shale, 8 mm. in maximum diameter.
3	„ 27 „	49 52 15	32 27 30	2054	Globigerina ooze	40	
4	„ 28 „	49 42 15	32 27 20	2075	—	—	
5	„ 28 „	49 47 15	32 35 15	2207	Globigerina ooze	40	
6	„ 28 „	49 47 15	32 16 40	2164	„ „	40	Black volcanic rock fragment, 2 × 1 cm.
7	„ 30 „	49 45 19	32 33 14	2150	„ „	40	
8	„ 31 „	49 50 30	31 42 30	1970	„ „	40	
9	June 2 „	49 56 52	31 42 30	1997	—	—	
10	„ 2 „	49 54 12	31 42 30	1803	Globigerina ooze	50	
11	„ 2 „	49 57 10	31 37 37	1989	„ „	50	
12	„ 3 „	49 56 30	31 29 10	1702	„ „	80	
13	„ 3 „	49 56 37	31 29 20	1776	„ „	80	
14	„ 3 „	49 56 30	31 27 40	1834	„ „	75	Specimens 11, 12, 13, 14, and 15, described by Dr. Flett.
15	„ 4 „	49 54 54	31 30 12	1134	—	—	
16	„ 4 „	50 1 19	31 14 10	2072	„ „	75	
17	„ 4 „	50 3 19	31 14 10	1980	„ „	75	
18	„ 4 „	49 59 19	31 14 10	2028	„ „	75	
19	„ 4 „	50 1 19	31 11 3	2069	„ „	70	
20	„ 4 „	50 1 19	31 17 7	2060	„ „	70	Appears to have been slightly washed in being brought to the surface; fragment of microcline felspar, 3 × 2 mm., observed.
21	„ 5 „	50 2 37	31 19 30	2100	„ „	—	
22	„ 5 „	50 1 18	31 17 48	2080	„ „	80	
23	„ 5 „	50 0 16	31 16 10	2078	„ „	80	
24	„ 5 „	50 0 18	31 13 50	2067	„ „	75	
25	„ 6 „	49 56 17	31 22 45	1599	—	—	Specimen 4, described by Dr. Flett.
26	„ 6 „	49 57 8	31 17 20	2002	„ „	80	
27	„ 6 „	49 59 13	31 18 16	2070	„ „	80	
28	„ 6 „	50 4 40	31 8 32	2005	„ „	80	
29	„ 7 „	49 59 54	31 7 44	2028	„ „	80	
30	„ 7 „	49 59 0	31 19 30	2091	„ „	80	
31	„ 7 „	49 51 35	31 38 0	1872	„ „	80	

No.	Date.	Latitude. ° ′ ″	Longitude. ° ′ ″	Depth. Fathoms.	Deposit.	$CaCO_3$ per cent.	Remarks.
32	June 7, 1903	49 51 27	31 33 53	1520	Globigerina ooze	70	
33	„ 8 „	49 52 17	31 30 12	1239	„ „	—	
34	„ 8 „	49 52 50	31 26 24	1679	„ „	80	Specimen 7, described by Dr. Flett.
35	„ 8 „	49 53 24	31 22 37	1714	„ „	—	
36	„ 8 „	49 53 58	31 18 50	1585	„ „	—	Small rounded volcanic rock fragments.
37	„ 8 „	49 54 32	31 15 4	1979	„ „	80	A few fragments of volcanic rock.
38	„ 8 „	49 55 4	31 11 17	1958	„ „	—	Small piece of volcanic rock coated with mammillary concretions of manganese.
39	„ 9 „	49 52 26	31 43 13	1966	„ „	80	
40	„ 9 „	49 54 21	31 43 38	2000	„ „	80	
41	„ 9 „	49 56 16	31 44 6	1903	„ „	80	
42	„ 10 „	49 58 57	31 35 56	1978	„ „	80	
43	„ 10 „	49 59 32	31 33 0	1868	„ „	80	
44	„ 10 „	50 0 8	31 29 54	1895	„ „	80	
45	„ 10 „	50 0 45	31 26 48	1916	„ „	90	
46	„ 10 „	50 3 34	31 4 30	2026	—	—	
47	„ 10 „	50 1 8	31 4 30	2054	—	—	
48	„ 15 „	50 3 54	31 0 10	1953	Globigerina ooze	75	
49	„ 15 „	50 0 55	30 59 18	2055	„ „	75	
50	„ 16 „	50 5 8	30 55 52	1764	„ „	75	Small rounded piece of slightly decomposed pumice.
51	„ 16 „	50 3 13	30 55 53	1778	„ „	80	
52	„ 16 „	50 1 20	30 55 59	1926	„ „	75	
53	„ 17 „	50 1 40	31 7 52	2049	„ „	75	
54	„ 18 „	50 0 20	31 5 47	2069	„ „	75	Specimen 8, described by Dr. Flett.
55	„ 19 „	49 56 30	31 41 30	1898	„ „	80	Specimen 10, described by Dr. Flett.
56	„ 19 „	50 4 0	30 58 0	1853	„ „	75	
57	„ 19 „	50 6 40	30 52 18	1717	„ „	80	
58	„ 19 „	50 5 9	30 51 40	1636	„ „	80	
59	„ 19 „	50 2 42	30 50 45	1577	„ „	80	
60	„ 20 „	50 6 45	30 48 55	1646	„ „	80	
61	„ 20 „	50 4 55	30 47 52	1550	„ „	—	Appears to have been partly washed in process of collection. Fragments of what appears to be a blue mud, with a high percentage of minerals, were obtained in the snapper; the mineral particles made up about 40 per cent., had a mean diameter of 0·15 mm., and consisted of quartz, felspars, hornblende, and volcanic glass, also magnetite and other minerals.

62	June 20, 1903	50 3 0	30 46 45	1460	Globigerina ooze	—	Specimens 1, 2, and 3, described by Dr. Flett.
63	„ 20 „	50 1 3	30 45 40	1723	„ „	80	
64	„ 22 „	50 5 0	31 1 17	1911	„ „	80	
65	„ 23 „	50 1 4	30 58 40	2039	„ „	70	
66	„ 23 „	50 2 13	30 55 22	1838	„ „	70	
67	„ 24 „	50 6 30	30 46 10	1617	„ „	80	
68	„ 24 „	50 7 18	30 42 15	1561	„ „	90	
69	„ 24 „	50 8 32	30 35 42	1850	„ „	80	
70	„ 24 „	50 9 15	30 31 45	1940	„ „	70	
—	„ 24 „	49 52 0	31 1 0	2039	„ „	—	Specimen 9, described by Dr. Flett.
71	„ 26 „	50 5 55	30 28 0	1850	„ „	70	
72	„ 26 „	50 7 7	30 34 38	1864	„ „	70	
73	„ 26 „	50 2 40	30 33 12	1714	„ „	80	
74	„ 27 „	50 2 30	30 37 30	1608	Pteropod ooze	80	
75	„ 27 „	50 3 0	30 28 20	1839	Globigerina ooze	70	
76	„ 27 „	50 3 20	30 25 10	1804	„ „	70	
77	„ 28 „	50 4 22	30 36 26	1700	„ „	—	Small piece of volcanic rock coated with manganese, 3 mm. in max. diameter.
78	„ 30 „	50 3 54	30 22 6	1770	„ „	80	Piece of dolomite, 3 × 2 cm. (almost pure $CaCO_3MgCO_3$).
79	„ 30 „	50 5 30	30 19 0	1898	„ „	80	
80	„ 30 „	50 2 12	30 17 54	1846	„ „	80	
81	July 1 „	50 5 52	30 24 45	1827	—	—	
82	„ 2 „	50 4 6	30 29 34	1862	Globigerina ooze	80	
—	„ 2 „	50 2 40	30 27 36	1840	—	—	Specimens 5, 6, 17, and 18, described by Dr. Flett.
83	„ 9 „	50 5 10	30 12 0	1759	Globigerina ooze	80	
84	„ 9 „	50 5 30	30 11 0	1656	—	—	
85	„ 10 „	49 54 55	31 38 55	1748	Globigerina ooze	—	Has the appearance of having been partly washed while being brought to the surface.
86	„ 14 „	49 52 10	31 57 0	1971	—	—	
—	„ 15 „	49 50 0	31 53 0	1960	—	—	Specimen 16, described by Dr. Flett.
87	„ 18 „	49 55 30	31 41 30	1883	Globigerina ooze	70	
88	„ 18 „	49 56 46	31 37 27	1639	„ „	80	
89	„ 21 „	49 48 40	31 59 6	2000	„ „	70	
—	—	49 49 12	31 18 15	2000	—	—	Small rounded fragment of volcanic rock.
—	„ 18 „	49 56 20	31 39 40	1700	Globigerina ooze	—	Appears to have been partly washed during process of collection.
—	„ 18 „	49 47 15	32 27 30	2193	„ „	70	
—	„ 18 „	49 47 15	32 27 30	2032	„ „	70	
—	„ 18 „	50 3 0	30 29 30	1840	Corals, etc.	—	Decomposed coral coated with manganese, and decomposed siliceous sponge.

DESCRIPTIONS OF THREE TYPICAL SAMPLES COLLECTED BY THE S.S. "FARADAY."

No. 3. MAY 27, 1903. LATITUDE 49° 52′ 15″ N., LONGITUDE 32° 27′ 30″ W., 2054 FATHOMS.

Globigerina Ooze, $CaCO_3$ (40 per cent.). Brownish-grey, coherent. Consisting of pelagic Foraminifera (*Globigerina bulloides*, *G. dubia*, *G. sacculifera*, *G. rubra*, *G. inflata*, *G. conglobata*, *G. æquilateralis*, *Pulvinulina menardii*, *P. micheliniana*, *P. tumida*, *Sphæroidina dehiscens*, *Orbulina universa*, *Pullenia obliquiloculata*), bottom-living Foraminifera (*Biloculina*, *Uvigerina*, *Cristellaria*), Echini spines, Ostracodes, coccoliths.

RESIDUE (60 per cent.). Flocculent brown clayey matter, with black mineral particles.

Minerals (50 per cent.). Made up of angular and rounded particles of quartz, hornblende, plagioclastic and other felspars, obsidian, and magnetite, with a mean diameter of 0·3 mm; the largest particle observed was 8 mm. in length, and consisted of a piece of shale.

Siliceous organisms (1 per cent.). Sponge spicules.

Fine washings (9 per cent.). Brownish-grey flocculent clayey matter, with minute mineral particles less than 0·05 mm. in diameter.

No. 68. JUNE 24, 1903. LATITUDE 50° 7′ 18″ N., LONGITUDE 30° 42′ 15″ W., 1561 FATHOMS.

Globigerina Ooze, $CaCO_3$ (90 per cent.). Light grey, coherent. Pelagic Foraminifera (*Globigerina bulloides*, *G. dubia*, *G. conglobata*, *G. æquilateralis*, *G. inflata*, *Sphæroidina dehiscens*, *Orbulina universa*, *Pullenia obliquiloculata*, *Pulvinulina micheliniana*, *P. tumida*, *P. menardii*, *P. canariensis*), Pteropods (*Clio australis*, *C. subula*, *Limacina*), bottom-living Foraminifera (*Miliolina*, *Lagena*, *Biloculina*, *Spiroloculina*), Echini spines, Ostracodes; many coccoliths, a few rhabdoliths, and one or two coccospheres were observed.

RESIDUE (10 per cent.). Light brown, flocculent.

Minerals (6 per cent.). Angular particles of felspar, quartz, hornblende, volcanic glass, magnetite, and microcline felspar, with a mean diameter of 0·2 mm. A small black non-magnetic spherule, having a diameter of 0·05 mm., was observed.

Siliceous organisms (1 per cent.). Sponge spicules.

Fine washings (3 per cent.). Amorphous clayey matter, with minute mineral particles less than 0·05 mm. in diameter.

No. 74. JUNE 27, 1903. LATITUDE 50° 2′ 30″ N., LONGITUDE 30° 37′ 30 W., 1608 FATHOMS.

Pteropod Ooze, $CaCO_3$ (80 per cent.). Grey, coherent. Pelagic Foraminifera (*Globigerina bulloides*, *G. conglobata*, *G. æquilateralis*, *G. inflata*, *G. sacculifera*, *G. dubia*, *Pulvinulina menardii*, *P. tumida*, *P. micheliniana*, *P. canariensis*, *Sphæroidina dehiscens*, *Orbulina universa*, *Pullenia obliquiloculata*), Pteropods (*Cavolinia*, *Clio subula*, *C. australis*, *Limacina*), Heteropods (*Atlanta*), bottom-living Foraminifera (*Amphistegina*, *Lagena*, *Miliolina*, *Spiroloculina*, *Truncatulina*, *Reophax*, *Biloculina*), *Serpula*, Echini spines, Polyzoa, Ostracodes, coccoliths, and rhabdoliths.

RESIDUE (20 per cent.). Yellowish-brown.

Minerals (10 per cent.). Angular, with a mean diameter of 0·3 mm., consisting of felspar, quartz, hornblende, magnetite, sphene, and small pieces of rock (coated with manganese), containing crystals of felspar, hornblende, and magnetite in a glassy base, the largest piece of rock observed being 6 × 4 mm.

Siliceous organisms (2 per cent.) Arenaceous Foraminifera, Sponge spicules, Radiolaria.

Fine washings (8 per cent.). Amorphous clayey matter, with minute mineral particles.

The deposit-samples brought home by Mr. Peake number 77, ranging in depth between 1520 and 2207 fathoms, of which 52 come from depths less than 2000 fathoms, and 25 from depths exceeding 2000 fathoms. Considering the limited area investigated—an area of about 140 miles from east to west by about 24 miles from north to south—and the limited range in depth, it is not surprising that the samples all practically belong to one type of deposit (Globigerina ooze), though one sample from 1608 fathoms contains so many remains of Pteropods and Heteropods that it has been called Pteropod ooze.

The percentage of carbonate of lime in these samples has been estimated by inspection, and it will be observed that this percentage varies from 40 to 90, the lower percentages being found in those samples from the greater depths.

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